Association between The Study of Nerve Conductivity and The Medianus Nerve Cross-Sectional Area in Carpal Tunnel Syndrome

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Abstract

Background: Carpal tunnel syndrome (CTS) is a collection of symptoms caused by clasps on median nerve. CTS diagnosis is based on anamnesis, physical examination and investigation. Medianus nerve electrodiagnostic examination is the gold standard of CTS diagnosis.

Objective: To determine the association between the study of nerve conductivity measured by electrodiagnostic and the median nerve cross-sectional area measured by musculoskeletal USG in CTS patients.

Methods: This study was conducted at medical rehabilitation installation of Dr. Soetomo Teaching Hospital Surabaya, Indonesia. The samples were 15 hand that obtained from 13 females with CTS.

Results: The Pearson Association analysis showed a significant positive correlation between the the cross-sectional area and the motor distal latency of medianus nerve ($r = 0.625$; $p = 0.013$). There was no significant correlation between the cross-sectional area with sensory distal latency, sensory amplitude, motor amplitude, sensory nerve conductivity velocity and motor nerve conductivity velocity of median nerve.

Conclusion: Electrodiagnostic and musculoskeletal USG have different roles in the diagnosis of CTS. Electrodiagnostics as the gold standard provided information about the level and severity of lesions n. Medianus. Musculoskeletal ultrasound could be used as an additional examination that provided information on the anatomy of median nerve and other structures located in the carpal tunnel.

Keywords: *nerve conductivity, cross section, median nerve, carpal tunnel syndrome.*

Introduction

Carpal tunnel syndrome (CTS) is a syndrome caused by the compression of the median nerve along the carpal tunnel [1]. This diseases occurs because gap in bottom arm to wrist the narrowing of causing can limit to function of the wrist [2]. CTS is the most common compression neuropathy [3] in the upper limb [4–6].

CTS release operations cost an approximately of 2 million dollars annually in the United States [4,7,8]. CTS diagnosis is based on anamnesis, physical examination and supported by an investigation. A frequent investigation of CTS is a neurophysiologic examination of median nerve using electromyography, meanwhile, structural examination of the median nerve and surrounding soft tissues using musculoskeletal ultrasonography (USG) to confirm the diagnosis of CTS and exclude other conditions [9]. Electrodiagnostics is still the only method available to assess the physiological

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changes that occur in CTS. Although electrodiagnostic examination had high sensitivity, however, false negative incidence was still reported to be about 8-12%, even a literature mentioned about 10-20% [10,11]. This examination might provide information about the level of the lesion, however, the information of median nerve spatial or surrounding tissue was not enough [10].

Musculoskeletal USG usage for the diagnosis of CTS is rare. Whereas the use of musculoskeletal USG can provide additional information that complements the electrodiagnostic results, thus it increases the diagnostic strength and management of CTS patients. The presence of additional information on the anatomy of the median nerve and surrounding structures may help to avoid misdiagnosis such as tenosynovitis or lesion due to tumors in median nerve, ganglion, fibroma [12].

Methods

This research was an observational analytic research with cross-sectional approach. The subjects of this study were CTS patients who visited the rehabilitation unit at Dr. Soetomo Teaching Hospital Surabaya from July to September 2014. CTS patients who fulfilled the inclusion criteria were performed electrodiagnostic and musculoskeletal USG examinations. All these examination were conducted within three days. The protocol of this study was approved by Dr. Soetomo Teaching Hospital Surabaya [13]. Data analysis was performed using SPSS 17. The data in this study was quantitative data, thus the analysis test used was Pearson correlation test.

Results

Subjects were 13 females, the mean age of the subjects was 45.8 ± 10.9 years, the youngest was 33 years old and the oldest was 60 years old. The mean body mass index (BMI) of subjects was 25.68 ± 3.4 kg/m^2 with the lowest BMI of 18.34 kg/m2 and the highest BMI of 31.53 kg/m2. One subjects had BMI less than 18.5 kg/m2, six subjects had BMI of 18.5-24.9 kg/m2, five subjects had BMI of 25-29.9 kg/m2, and a subject with BMI >30 kg/m2.

Two subjects had the occupation history of factory labour, office employees of 8 people, and housewife as many as 3 people. All subjects were right-hand dominance. Subjects with bilateral CTS was 8 patients and subjects with unilateral CTS was 5 patients (CTS on the right side was 4 people and CTS on the left side was 1 person). The mean duration of CTS symptoms in this subjects was 4.5 ± 2.4 months, the fastest duration was 1 month and the longest was 10 months (Table 1).

Results of Nerve Conductivity Study

Electrodiagnostic in 15 subjects obtained abnormal nerve in 5 subjects (Table 2).

Musculoskeletal USG Examination Results

All samples were performed an examination of muskuloskeletal USG. (table 3).

Correlation between The Study of Nerve Conductivity and The Median Nerve Cross-Sectional Area

There was no significant correlation was found between cross-sectional area with sensory KHS of median nerve (r = -0.291, p = 0.293), and between the cross-sectional area with motor amplitudes of median nerve (r = 0.385; p = 0.156) (Table 4).

Table 1. Subjects Characteristics

Variables	Frequency	Mean	Minimum	Maximum
Age (years) 31-40 41-50 51-60	 5 (38.4%) 3 (23.2%) 5 (38.4%)	45,8 ± 10,9	33	60
Sex				

***Cont...* Table 1. Subjects Characteristics**

Male Female	0 (0%) 13 (100.0%)			
Occupation				
Laborer Office workers Housewives	2(15.3%) 8(61.5%) 3(23.2%)			
BMI: Body Mass Indeks (kg/m2) <18.5 18.5-24.9 25-29.9 >30	1 (7.7%) 6 (46.1%) 5 (38.5%) 1 (7.7%)	25.68 ± 3.4	18.34	31.53
Hand dominance				
Right Left	13(100%) 0(0%)			
CTS symptom duration (months)		4.5 ± 2.4	1	10
Clinical CTS				
Bilateral Unilateral Only Left Only Right	8 (61.5%) 5 (38.5%) 4 (30.8%) 1(7.7%)			

Table 2. Results of Nerve Conductivity Study

Variables	Frequency	Mean	Minimum	Maximum
Sensoric-Distal Latency Abnormal Normal	2(13.33%) 13(86.67%)	2.90 ± 0.55	2.25	4.34
Sensoric-Amplitude Abnormal Normal	0(0%) 15(100%)	33.57± 13.91	8.40	66.50
Motors- Distal Latency Abnormal Normal	4(26.67%) 11(73.33%)	3.90±0.57	2.88	4.79
Motors-Amplitude Abnormal Normal	0 (0%) 15(100%)	7.01±1.68	4.30	10.30
Motors- KHS Abnormal Normal	0(0%) 15(100%)	57.97±4.48	51.40	65.10

Tabel 3. Muskuloskeletal USG (Ultrasonografi)

Variables	Frequency	Mean	Minimum	Maximum
Cross-section area of median nerve (mm2) Normal Abnormal	15 3(20%) 12 (80%)	12.87±3.26	5.67	19.00
Tendon flexor digitorum muscle				
Hyperechoic Normoechoic Hypoechoic	4 (26.67%) 8(53.33%) 3(20%)			
Tenosynovitis				
Yes No	0(0%) 15(100%)			
Lesions urge space				
Yes No	0(0%) 15(100%)			
Other discoveries				
Bifid median nerve	1			

Table 4. Correlation between Nerve Conductivity Study and Cross-Section Area of Median Nerve

		Cross-Section Area of Median Nerve
Sensoric-Distal Latency	r p N	0.099 0.725 15
Sensoric-Amplitude	r p N	-0.68 0.808 15
Sensoric-KHS	r p N	-0.291 0.293 15
Motors- Distal Latency	r p N	0.625* 0.013 15
Motors-Amplitude	r p N	0.385 0.156 15
Motors-KHS	r p N	0.142 0.614 15

Description:

r: correlation coefficient

p: p value indicates probability or level of significance.

*significant correlation at $p < 0.05$ (2-tailed)

Discussion

Thirteen females were enrolled in this study in order to avoid the influence of sex on the results of the examination. Carpal Tunnel Syndrome is more common in female than male [11]. The prevalence of CTS in the general population was about 5.3% in female and 2.1% in male [8]. The median nerve cross section area at the proximal level of the carpal tunnel was greater in male than female, although it was statistically insignificant [14]. The results of a nerve conductivity study at median nerve and ulnaris showed that female have higher sensory amplitude, shorter distal latency and faster KHS than male [15].

The mean age of the subjects was 45.8 ± 10.9 years, the youngest was 33 years old and the oldest was 60 years old. Brault (2007) [4] stated that female at the age of 40-60 years old were more likely to experience CTS. The most findings was found in the subjects at the age group of 31-40 years and 51-60 years. This showed that age was not the only factor for CTS.

Three groups of occupation were obtained namely labour factory, office workers and housewives. Huisstede et al., stated that CTS was related to the frequency of hand-arm vibrations, working with the wrists on long flexion or extension positions, working on continuous hand forces, with repetitive motions or combinations of all the mentioned items [5].

One subjects had BMI less than 18.5 kg/m2, six subjects had BMI of 18.5-24.9 kg/m2, five subjects had BMI of 25-29.9 kg/m2, and a subject with BMI >30 kg/m2. Data from the literature on the effect of BMI on the tendency of CTS incidence showed variant results. Some literature suggested a correlation between BMI and the tendency of CTS [16,17] however other stated they were unrelated [18]. This might be due to BMI calculations did not include the ratio of fat and muscle [19].

All subjects of this study were right-handed. Subjects with bilateral CTS were 8 people and unilateral CTS of 5 people (CTS on the right side as many as 4 people and CTS on the left side of 1 person). This was consistent with the literature which stated the hands on the dominant side were at greater risk of CTS due to greater physical activity [19].

Electrodiagnostic results in 15 sample units using clinical diagnosis of CTS obtained 5 samples (33.33%) with abnormal nerve. Two hands with extended sensory distal latency (13.33%) meanwhile, the normal sensory amplitudes were in all samples. The number of samples with extended distal motor latency extends was 4 hands (26.67%) while the motor amplitudes were normal in all samples. The extended distal latency and decreased of nerve conduction velocity indicated the demyelination of the nerve fibers, whereas the axon abnormality would result in a decrease in the amplitude of the nerve action potential [20].

There were 5 samples who had lesions of demyelination and no samples had axonal lesions. The results of a normal nerve conductivity study with a clinical diagnosis of CTS obtained 9 samples. This might be due to a nerve conductivity study using Johnson's cut-off value [21]. Electrodiagnostic examination was the best and most reliable examination for confirmation of CTS diagnosis that had high sensitivity and specificity [6].

The mean of median nerve cross-sectional area was 12.87 ± 3.26 mm2, ranging from 5.67 mm2 to 19.00 mm2. The number of samples with the abnormal cross-sectional area was 12 hands (80%) with a cut-off value of 10 mm2. This result was consistent with the literature that musculoskeletal USG examination in CTS showed a magnification of median nerve [22]. Mechanical compression and local ischemia in median nerve on the carpal tunnel caused the onset of CTS symptoms. The continuous increase in pressure and long duration caused a change in function and structure of the median nerve. It resulted in a intraneural edema that might progress into fibrotic scars. This change appeared to be a median nerve enlargement on USG examination [9].

There were no lesions on space for all examined hands. CTS due to the lesions urge space was rare, however, complications were often more severe. Chen et al., documented 23 of the 779 patients who performed

CTS release had lesions urged space due to gout arthritis, lipoma, fibroma and ganglion cyst [23]. Ozden et al, [24] also documented that 12 of 410 CTS patients were caused by space-induced lesions. Lesions urged space were identified from USG, MRI and CT scans [24]. Information on the existence of lesions urged space were used as a consideration in the determination of therapy about the possibility of surgery [24,25].

We obtained one hand sample with variation anatomy of bifid median nerve. The bifid median nerve was also obtained in several studies. Padua et al. found two patients with a bifid median nerve from 54 CTS patients. Bifid median nerve using USG examination in 32 of 170 CTS cases and 11 of 120 controls. Cross section area of bifid median nerve was relatively larger than non-bifid [26]. Incident of bifid median nerve in CTS patients was about 0.8-2.8% and it was often accompanied by persistent median arteries. The bifid median nerve was often associated with compression median nerve in the carpal tunnel because it was relatively larger in size compared to the normal median nerve [26–28]. The presence of bifid median nerve was considered in the determination of therapy, especially surgical therapy because surgeons will consider the possibility of a persistent median artery. The presence of a two-nerve compartment considered other actions except for decompression action; it might be necessary to have epineurectomy [28].

This study found a significant positive correlation between the cross-sectional area with a motor distal latency of median nerve. Extended motor distal latency, the cross-section area of median nerve was getting bigger. This might be due to the motor nerve fibers had a larger size than the sensory nerve fibers. Large nerve fibers were more susceptible to ischemia and compression than small nerve fibers [29]. Large fascicides and wrapped in thin epineurium layers would experience heavier compression than small fascicides wrapped in thick epineurium [29]. Increased carpal tunnel pressure caused compression in all the components inside, including compression in the median nerve. Repeated compression of the median nerve caused a focal demyelination. This initial demyelination occurred in areas that compressed and it spread throughout the internodal segments that caused obstacles to neural transmission (neuropraxia) [9,30]. Continuous compression resulted in a disruption of the endoneurial blood flow of the endoneurial capillary system and caused endoneurium edema. Venous congestion, ischemia and local metabolic changes caused the inflammatory process to continue and axonal degeneration occurred. Chronic inflammation caused fibrosis in the advanced stage that would inhibit nerve gliding, it caused trauma and the formation of a scar on the mesoneurium median nerve. These changes were seen as median nerve enlargement on USG examination [9,30].

There were several potentially confounding factors in determining the cut-off value of the cross-sectional area of abnormal median nerve. The reason was the cross-section area of median nerve might be affected by race, sex and BMI. USG could not determine the severity of neuropathy median nerve as electrodiagnostic examination. The cross-section area of median nerve with a demyelinating lesion was sometimes greater than those with severe axonal lesions [31].

Conclusion

There was a correlation between motor distal latency and cross-sectional area in CTS patients, however, no correlation between sensory distal latency and cross-sectional area of median nerve was found in this study.

Conflict of Interest : There is no conflict of interest

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Ethical Clearance : This study was approved by Ethical Commission of Health Research Faculty of Medicine University of Airlangga

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